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HOST SPECIFICITY AND BIOLOGY OF *BUCCULATRIX IVELLA* BUSCK, A POTENTIAL BIOLOGICAL CONTROL AGENT FOR *BACCHARIS HALIMIFOLIA* L. IN AUSTRALIA

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ABSTRACT. Life history and host range of *Bucculatrix ivella* were investigated as part of a program to find host-specific biocontrol agents for *Baccharis halimifolia* in Australia. This multivoltine insect was collected on *B. halimifolia* and *B. neglecta* from Texas to New Jersey. Though usually found at low population densities, it occasionally occurred in numbers sufficient to defoliate plants. Host specificity tests of oviposition preference and larval feeding indicated that *B. ivella* was specific to *Baccharis* species. These tests and a field survey indicated that *Iva frutescens* is definitely not a host although it is reported as such in the literature. *Bucculatrix ivella* has been approved for introduction into Australia for the control of *B. halimifolia*.

Additional key words: Lyonetiidae, *Baccharis neglecta*, *Iva frutescens*, introduction, weed.

Following its introduction into Queensland, Australia, before 1900, the North American shrub *Baccharis halimifolia* L. (Asteraceae: Astereae: Baccharineae) has become a serious weed in SE Queensland and NE New South Wales by invading pastures and land cleared for reforestation. The plant was declared noxious in 1951; subsequently a biological control program to find and introduce suitable host specific insects from the New World was implemented. This program consisted of intensively surveying appropriate areas, selecting stenophagous species from available knowledge, testing the host range of these species experimentally and, if their host range was limited to *Baccharis*, mass rearing and releasing in Australia.

One such candidate from the surveys of the fauna on *B. halimifolia* and *B. neglecta* Britt. (Palmer 1987, Palmer & Bennett, in prep.) was the leafminer *Bucculatrix ivella* Busck. This insect was first reported on *Iva frutescens* L. (Busck 1904), but since has been reported only from *B. halimifolia* (Braun 1963, R. W. Hodges, pers. comm.). However, we suspected the host record on *I. frutescens* may have been in error when another species, *Aristotelia ivella* Busck (Gelechiidae), collected by H. Dyar from the same plants (Busck 1904) proved to be specific to *Baccharis*.

The genus *Bucculatrix* is cosmopolitan with about half the species found in America north of Mexico. Braun (1963) described 99 species, including 50 new species, that occur in this region. Little taxonomic work has been done on the genus since, and there are undoubtedly many undescribed species (R. W. Hodges, pers. comm.). Although the known food plants include 25 plant families, nearly ⅔ of *Bucculatrix* species were associated with Asteraceae, and more than ¾ were recorded from a single plant genus (Braun 1963). Braun (1963) listed three pest species: *B. thurberiella* Busck, *B. canadensisella* Chambers, and *B. pomifoliiella* Clemens, which attack cotton, birch, and apple, respectively. An undescribed *Bucculatrix* has already been released in Australia for control of the weed *Parthenium hysterophorus* L.

At least four species are associated with *Baccharis*. In addition to *Bucculatrix ivella*, *B. separabilis* Braun, and *B. variabilis* Braun are associated with *Baccharis pilularis* DC. in California (Braun 1963). Recently, we collected an undescribed species from *B. sarathroides* Gray in Arizona.

This paper reports results of experimental and field observations undertaken to investigate the host specificity of *Bucculatrix ivella*. In the course of the study, biology and phenology of *B. ivella* were observed and are also reported.

BIOLOGY

The biology of *B. ivella* is typical of leaf-mining species of *Bucculatrix* described by Braun (1963). The following description is based on numerous laboratory and field observations of life stages. Eggs were whitish, translucent, and flatish ovoid in shape, and were cemented to the leaf surface, usually along the upper surface of the midrib of the leaf. In sunlight they had a characteristic iridescence and were thus easily recognized.

Larvae hatched within 7–11 days and entered the leaf tissue directly where they mined the parenchyma. Mines were distinctive threadlike tracks which initially followed a leaf vein but eventually became irregular, serpentine, and black with the deposition of frass. Larvae spent the first, second, and part of the third instars in these mines. After leaving the mines, they spun flat, thin "molting cocoons" under which they molted. Fourth and fifth instars were external feeders, and a second "molting cocoon" was formed at the end of the fourth instar. Larvae were found on either upper or lower leaf surfaces, although the latter were more commonly infested. When disturbed, larvae dropped on a silken thread. They consumed leaf tissue in patches but left the opposite epidermal tissue intact, which produced a "window" effect.

TABLE 1. Number of plants infested with *Bucculatrix ivella* after exposure in a glasshouse.

Plant species (Tribe)	Number examined	Number infested
Baccharis halimifolia L. (Astereae)	3	2
B. neglecta Britton (Astereae)	5	2
B. glutinosa (R. & P.) (Astereae)	1	0
B. pilularis DC. (Astereae)	1	0
Solidago altissima L. (Astereae)	1	0
Haplopappus tenuisectus (Green) Blake (Astereae)	2	0
Aster novae-angliae L. (Astereae)	2	0
Conyza canadensis (L.) (Astereae)	1	0
Iva frutescens L. (Heleantheae)	10	0
Leucanthemum maximum Ramond (Anthemideae)	5	0
Ageratum houstonianum Mill. (Eupatoreae)	2	0

Pupation occurred within characteristic ribbed cocoons spun on leaves and stems of *Baccharis*. However, when larvae were abundant, some left the host to pupate on neighboring plants or in ground debris.

Before eclosion, the pupa thrust through the anterior end of the cocoon, exposing about half its length. Pupal cases remained attached to cocoons after moth emergence. Moths remained quiescent on foliage during the day and became active at dusk.

HOSTS, DISTRIBUTION AND PHENOLOGY

Bucculatrix ivella has been collected nearly throughout the range of *Baccharis halimifolia*; we collected it in New Jersey, Virginia, Florida, Louisiana, and Texas. In Texas, the immatures were most abundant in late April and early May, when infested plants had 50–100 larval mines, but after early spring few individuals were seen. In Florida, the life cycle was completed in 4–6 weeks and larvae were found at most times of the year. Several hundred mines per plant were observed in Virginia and New Jersey in June and July, and these populations caused severe defoliation. It is perhaps the most abundant lepidopteran associated with *B. halimifolia*.

In central Texas, *Bucculatrix ivella* was collected from *Baccharis neglecta*, which is a new host record. However, natural populations on this species were invariably low, even though it breeds readily on this plant under glasshouse conditions.

Collections of *Bucculatrix ivella* immatures invariably contained a proportion (10–90%) of parasitized specimens. Among the parasites to emerge were species of the hymenopterans *Ageniaspis* (Encertidae), *Apanteles* (Braconidae), *Bucculatriplex* (Braconidae), *Cirrospilus* (Eulophidae), *Mirax* (Braconidae), *Opius* (Braconidae) and *Tetrastichus* (Eulophidae).

TABLE 2. Degree of infestation by *Bucculatrix ivella* on six plants in an unreplicated cage experiment.

Plant species (Tribe)	Infestation
Baccharis halimifolia L. (Astereae)	13 larval mines 20 larval cocoons 5 late instars external feeding damage >60 pupal cocoons
Aster novae-angliae L. (Astereae)	none
Solidago altissima L. (Astereae)	none
Callistephus chinensis (L.) Nees (Astereae)	none
Cynara scolymus L. (Cardueae)	none
Iva frutescens L. (Heleantheae)	none

HOST SPECIFICITY

Host specificity was determined by laboratory trials and field observations designed first to demonstrate whether *Iva frutescens* in particular, and Asteraceous plants in general, were hosts, and second, to test the insect against a wide variety of plants of economic importance to Australia.

Field observations. In Virginia and New Jersey, *Baccharis halimifolia* heavily infested with *Bucculatrix ivella* was found growing close to *Iva frutescens*. Sometimes the branches of the two intertwined. *Iva frutescens* was carefully searched without ever finding an infestation of *Bucculatrix ivella*.

The area where the report on *Iva frutescens* originated (Palm Beach, Florida) was also searched. However, *I. frutescens* was not found there; it is apparently rare S of Daytona Beach, Florida, while *Baccharis halimifolia* is common.

Larval feeding. On four occasions over a two-year period, late instars were collected from *B. halimifolia* and returned to the laboratory where 5 to 10 were placed on bouquets of *B. halimifolia* and *I. frutescens*. Larvae invariably continued feeding and pupated on the *B. halimifolia*, but no evidence of feeding was found on the *I. frutescens*.

Glasshouse observations. Potted asteraceous plants were introduced into a glasshouse containing potted *Baccharis* plants infested with *Bucculatrix ivella*. After two months, the plants were carefully examined for infestations of *B. ivella*. Only *Baccharis halimifolia* and *B. neglecta* were infested (Table 1).

Cage experiment. A cage experiment was conducted in a glasshouse using *B. halimifolia* and five other asteraceous species common in Australia. One potted plant of each species was placed in a wooden cage with a clear plastic top. Thirty pupae and four moths were introduced together with four sugar-water wicks. When the *B. halimifolia* plant was infested, all plants were removed and carefully examined. A number of infestations were found on the *B. halimifolia*, but none of the other plants was infested (Table 2).

Comprehensive testing. Before permission to release the insect in Australia could be sought, *Bucculatrix ivella* had to be tested against the complete list of plants suggested by the Commonwealth Department of Health (Table 3). Oviposition preference was tested using a 5.0 × 4.5 × 3.0 m glass-sided cage into which were randomly placed young, actively growing tip cuttings of all test plants and *Baccharis halimifolia*. These cuttings were held in glass vials with water. Twenty moths were placed in the cage together with a honey-water mixture. After 6 days, when the *B. halimifolia* was infested with eggs, the cuttings were carefully examined and any eggs counted. After a further six days, when larval mines were seen in *B. halimifolia* leaves, the cuttings were reexamined for eggs or mines. The experiment was replicated twice. Numbers of eggs and larval mines were seen on all *B. halimifolia* cuttings, but not on any other cutting.

In a second experiment, host range of the ectophagous late instars was tested. Five fourth or fifth instars collected from the field were placed on two potted plants of each

TABLE 3. Plant species against which *Bucculatrix ivella* was tested to obtain permission for its introduction into Australia.

Apiaceae: *Daucus carota* L.; *Pastinaca sativa* L.
Anacardiaceae: *Mangifera indica* L.
Asteraceae: *Baccharis halimifolia* L.; *Carthamus tinctorius* L.; *Chrysanthemum* sp.; *Dhalia* sp.; *Helianthus annuus* L.; *Lactuca sativa* L.
Brassicaceae: *Brassica oleraceae* (L.) Alef.; *Brassica rapa* L.
Bromeliaceae: *Ananas comosus* (L.) Merr.
Caricaceae: *Carica papaya* L.
Chenopodiaceae: *Beta vulgaris* L.
Convolvulaceae: *Ipomoea batatas* (L.) Lam.
Cucurbitaceae: *Cucumis melo* L.; *Cucumis sativus* L.; *Curcubita maxima* Duch.
Fabiaceae: *Arachis hypogaea* L.; *Centrosema pubescens* Benth.; *Desmodium canum* (Gmel.); *Glycine wightii* (R. Grah. ex Wight & Arn.) Verdc.; *Glycine max* (L.) Merr.; *Medicago sativa* L.; *Phaseolus atropurpureus* DC.; *Phaseolus vulgaris* L.; *Pisum sativum* L.; *Stizolobium* sp.; *Stylosanthes gracilis*; *Trifolium repens* L.; *Vigna catjang* V.
Linaceae: *Linum usitatissimum* L.
Malvaceae: *Gossypium hirsutum* L.
Mimosaceae: *Leucaena leucocephala* (Lam.) de Wit.
Musaceae: *Musa sapientum* M.
Passifloraceae: *Passiflora edulis* Sims
Pinaceae: *Pinus radiata* D. Don.; *Pinus taeda* L.
Poaceae: *Avena sativa* L.; *Digitaria decumbens* Stent.; *Panicum maximum* Jacq.; *Paspalum dilatatum* Poir.; *Pennisetum clandestinum* Chiov.; *Saccharum officinarum* L.; *Sorghum vulgare* L.; *Triticum aestivum* L.; *Zea mays* L.
Proteaceae: *Macadamia integrifolia* Maid & Betche
Rosaceae: *Fragaria vesca* L.; *Malus sylvestris* Mill.; *Prunus domestica* L.; *Prunus persica* (L.) Batch.; *Pyrus communis* L.; *Rosa* sp.
Rutaceae: *Citrus limon* (L.) Burm. F.; *Citrus paradisi* Macfady.; *Citrus reticulata* Blanco; *Citrus sinsensis* (L.)
Sapindaceae: *Litchi chinensis* Sonn.
Solanaceae: *Capsicum annuum* L.; *Lycopersicum esculentum* Miller; *Nicotiana tabacum* L.; *Solanum tuberosum* L.
Vitaceae: *Vitis vinifera* L.
Zingiberaceae: *Zingiber officinale* Roscoe.

species, which were observed for 10 days. Larvae on all plants other than *B. halimifolia* were seen leaving the plants in the first two days, and no feeding was attempted on them. On the other hand, all larvae on *B. halimifolia* were seen to feed normally.

DISCUSSION

The tests conducted on *Bucculatrix ivella* clearly showed its specificity to some species of *Baccharis* such as *B. halimifolia* and *B. neglecta*; also that *Iva frutescens* was not a suitable host. The most likely explanation for the record on *I. frutescens* is that *B. halimifolia* was misidentified as that species. The two are morphologically similar and grow in similar habitats. They are both known by the same common name, "salt bush". A second explanation is that if the two plant species were growing together, late instars could have migrated onto the *I. frutescens*

to pupate. This is less likely because *I. frutescens* does not grow, or is rare, in Palm Beach Co., Florida, where the collection was made.

Bucculatrix ivella has considerable potential as a biocontrol agent and is also relatively easy to rear and handle in the laboratory. It is multivoltine and capable of building up to high populations that greatly damage the plant. In North America, it is heavily parasitized, but before release in Australia it will be freed of parasites. In the absence of parasites, the rate of population growth in Australia should be greater than in its native habitat.

Permission to import this insect into Australia was granted in 1986.

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